



Blocking Filters With Enhanced Throughput for X-Ray Microcalorimetry

Polyimide replaces the standard metal mesh.

Goddard Space Flight Center, Greenbelt, Maryland

New and improved blocking filters (see figure) have been developed for microcalorimeters on several mission payloads, made of high-transmission polyimide support mesh, that can replace the nickel mesh used in previous blocking filter flight designs. To realize the resolution and signal sensitivity of today's x-ray microcalorimeters, significant improvements in the blocking filter stack are needed.

Using high-transmission polyimide support mesh, it is possible to improve overall throughput on a typical microcalorimeter such as Suzaku's X-ray Spectrometer by 11%, compared to previous flight designs. Using polyimide to replace standard metal mesh means the mesh will be transparent to energies 3 keV and higher. Incorporating polyimide's advantageous strength-to-weight ratio, thermal stability, and transmission characteristics permits thinner filter materials, significantly enhancing through-



SUVI (Solar Ultraviolet Imager) Entrance Filter Prototype —150 nm Al on 70 lpi polyimide mesh and an ASTRO-H DMS filter prototype — 80 nm Al on 100 nm polyimide with 70 lpi polyimide mesh.

put. A prototype contamination blocking filter for ASTRO-H has passed QT-level acoustic testing. Resistive traces can also be incorporated to provide decontamination capability to actively restore filter performance in orbit.

This work was done by David Grove, Jacob Betcher, and Mark Hagen of Luxel Corp. for Goddard Space Flight Center. Further information is contained in a TSP (see page 1). GSC-16292-1

High-Thermal-Conductivity Fabrics

Applications include cooling garments for firefighters, hazmat personnel, soldiers, and in cooling vests for multiple sclerosis patients.

Lyndon B. Johnson Space Center, Houston, Texas

Heat management with common textiles such as nylon and spandex is hindered by the poor thermal conductivity from the skin surface to cooling surfaces. This innovation showed marked improvement in thermal conductivity of the individual fibers and tubing, as well as components assembled from them.

The problem is centered on improving the heat removal of the liquid-cooled ventilation garments (LCVGs) used by astronauts. The current design uses an extensive network of water-cooling tubes that introduces bulkiness and discomfort, and increases fatigue. Range of motion and ease of movement are affected as well. The current technology is the same as developed during the

Apollo program of the 1960s. Tubing material is hand-threaded through a spandex/nylon mesh layer, in a series of loops throughout the torso and limbs such that there is close, form-fitting contact with the user. Usually, there is a nylon liner layer to improve comfort. Circulating water is chilled by an external heat exchanger (sublimator).

The purpose of this innovation is to produce new LCVG components with improved thermal conductivity. This was addressed using nanocomposite engineering incorporating high-thermal-conductivity nanoscale fillers in the fabric and tubing components. Specifically, carbon nanotubes were added using normal processing methods such as

thermoplastic melt mixing (compounding twin screw extruder) and downstream processing (fiber spinning, tubing extrusion). Fibers were produced as yarns and woven into fabric cloths. The application of isotropic nanofillers can be modeled using a modified Nielsen Model for conductive fillers in a matrix based on Einstein's viscosity model.

This is a drop-in technology with no additional equipment needed. The loading is limited by the ability to maintain adequate dispersion. Undispersed materials will plug filtering screens in processing equipment. Generally, the viscosity increases were acceptable, and allowed the filled polymers to still be processed.

The novel feature is that fabrics do not inherently possess good thermal conductivity. In fact, fabrics are used for thermal insulation, not heat removal. The technology represents the first material that is a wearable fabric, based on company textiles and materials that will significantly conduct heat.

This work was done by L. P. Felipe Chibante of NanoTex Corporation for Johnson Space Center. Further information is contained in a TSP (see page 1).

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

*NanoTex Corporation
9402 Alberene Dr.
Houston, TX 77074*

Refer to MSC-24389-1, volume and number of this NASA Tech Briefs issue, and the page number.

Imidazolium-Based Polymeric Materials as Alkaline Anion-Exchange Fuel Cell Membranes

Polymer electrolyte membrane fuel cells can be used for portable power sources.

NASA's Jet Propulsion Laboratory, Pasadena, California

Polymer electrolyte membranes that conduct hydroxide ions have potential use in fuel cells. A variety of polystyrene-based quaternary ammonium hydroxides have been reported as anion exchange fuel cell membranes. However, the hydrolytic stability and conductivity of the commercially available membranes are not adequate to meet the requirements of fuel cell applications. When compared with commercially available membranes, polystyrene-imidazolium alkaline membrane electrolytes are more stable and more highly conducting. At the time of this reporting, this has been the first such usage for imidazolium-based polymeric materials for fuel cells.

Imidazolium salts are known to be electrochemically stable over wide po-

tential ranges. By controlling the relative ratio of imidazolium groups in polystyrene-imidazolium salts, their physiochemical properties could be modulated.

Alkaline anion exchange membranes based on polystyrene-imidazolium hydroxide materials have been developed. The first step was to synthesize the poly(styrene-co-(1-((4-vinyl)methyl)-3-methylimidazolium) chloride through a free-radical polymerization. Casting of this material followed by *in situ* treatment of the membranes with sodium hydroxide solutions provided the corresponding hydroxide salts. Various ratios of the monomers 4-chloromethylvinylbenzene (CMVB) and vinylbenzene (VB) provided various compositions of the

polymer. The preferred material, due to the relative ease of casting the film, and its relatively low hygroscopic nature, was a 2:1 ratio of CMVB to VB.

Testing confirmed that at room temperature, the new membranes outperformed commercially available membranes by a large margin. With fuel cells now in use at NASA and in transportation, and with defense potential, any improvement to fuel cell efficiency is a significant development.

This work was done by Sri R. Narayan and Shiao-Ping S. Yen of Caltech, and Prakash V. Reddy and Nanditha Nair of Missouri University of Science and Technology for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-46457

Electrospun Nanofiber Coating of Fiber Materials: A Composite Toughening Approach

Companies could apply this technology in producing fabric products for use in composite manufacturing.

John H. Glenn Research Center, Cleveland, Ohio

Textile-based composites could significantly benefit from local toughening using nanofiber coatings. Nanofibers, thermoplastic or otherwise, can be applied to the surface of the fiber tow bundle, achieving toughening of the fiber tow contact surfaces, resulting in tougher and more damage-resistant/tolerant composite structures. The same technique could also be applied to other technologies such as tape laying, fiber placement, or filament winding operations. Other modifications to the composite properties such as thermal and

electrical conductivity could be made through selection of appropriate nanofiber material.

Investigations of the failure and damage mechanisms of textile composites has led to the conclusion that toughening of the matrix material would result in increased material performance. Several approaches exist in which the bulk of the matrix is modified either through chemical formulation or the addition of fillers. These methods can detrimentally affect the processability of the resulting matrix material. Other methods exist

that rely on modification of the fiber material (so-called "fuzzy fiber" approaches) that results in reduced fiber performance.

Control of the needle electric potential, precursor solution, ambient temperature, ambient humidity, airflow, etc., are used to vary the diameter and nanofiber coating morphology as needed. Post-coating heat treatments may also be used for the purpose of curing, drying, oxidation, annealing, etc. The array of electrospinning jets may be varied as needed to achieve uniform,